all the torsional effects are modified by the mechanical and magnetic properties of that substance.

Each current leaves a residuary magnetic effect in the bar, amounting in iron to about one tenth of its original influence. The residuary magnetism of coil-currents is affected and sometimes reversed by axial ones; and that of axial currents is also removed by coil ones, and by a red heat. The condition left by an axial current is smaller in degree and less stable, in a vertical iron wire or one in the terrestrial magnetic meridian, than that left by a coil one, partly because of the influence of terrestrial magnetism; but in a position at right angles to that the effect is different.

The torsion produced by a coil-current may be used as a test, and partly as a measure, of the residuary effect of an axial one; and that produced by an axial current may be employed to detect, and to some extent measure, ordinary magnetism in the bar. As an opposite coil-current at once reverses the ordinary longitudinal magnetism of a bar of iron, so also an opposite axial one at once reverses its transverse magnetism.

Many instances have been met with in which the transverse and longitudinal magnetic states produced by the two currents coexisted in the same substance. The torsional influence of the excited helix is distributed equally throughout its length; so also is that of the current in the bar. All the torsions are closely related to the well-known electric sounds, and to particular positions and internal movements of the particles of the iron.

Signs of electrotorsion were obtained with a bar of nickel, but not with wires of platinum, silver, copper, lead, tin, cadmium, zinc, magnesium, aluminium, brass, or German-silver, nor with a thick rod of zinc, or a cord of gutta percha.

January 15, 1874.

JOSEPH DALTON HOOKER, C.B., President, in the Chair.

The following Paper was read:—

I. "Preliminary Account of an Investigation on the Transmission of Sound by the Atmosphere." By JOHN TYNDALL, D.C.L., LL.D., F.R.S. Received January 1st, 1874.

This notice embraces the scientific results of an inquiry on Fog-signals, undertaken at the instance of the Elder Brethren of the Trinity House, and communicated with their friendly concurrence to the Royal Society.

The investigation was begun on the 19th of May, 1873, and continued till the 4th of July. It was resumed on the 8th of October, and con-

tinued to the end of November. It also includes observations made during the dense fog which enveloped London on December 9 and the succeeding days.

Gongs and bells were excluded from this investigation, in consequence of their proved inferiority to other instruments of signalling. The experiments were made with trumpets blown by powerfully compressed air, with steam-whistles, guns, and a steam syren, associated with a trumpet 16 feet long.

Daboll's horn, or trumpet, had been highly spoken of by writers on fog-signals. A third-order apparatus of the kind had been reported as sending its sound to a distance of from 7 to 9 miles against the wind, and to a distance of 12 to 14 miles with the wind. Holmes had improved upon Daboll; and with two instruments of Holmes, not of the third but of the first order, our experiments were made. On the 19th of May at 3 miles distance they became useless as a fog-signal; at a distance of 4 miles, with paddles stopped and all on board quiet, they were wholly unheard. At a distance of 2 miles from the Foreland the whistles tested on May 19 became useless. The 12 o'clock gun, fired with a 1 lb. charge at Drop Fort in Dover, was well heard on May 19, when the horns and whistles were inaudible. On the 20th of May the permeability of the atmosphere had somewhat increased, but the steam-whistle failed to pierce it to a depth of 3 miles. At 4 miles the horns, though aided by quietness on board, were barely heard. By careful nursing, if I may use the expression, the horn-sounds were carried to a distance of 6 miles. The superiority of the 18-pounder gun, already employed by the Trinity House as a fog-signal, over horns and whistles was on this day so decided as almost to warrant its recommendation to the exclusion of all the other signals.

Nothing occurred on the 2nd of June to exalt our hopes of the trumpets and whistles. The horns were scarcely heard at a distance of 3 miles; sometimes indeed they failed to be heard at 2 miles. By keeping every thing quiet on board, they were afterwards heard to a distance of 6 miles—a result, however, mainly due to the improved condition of the atmosphere. Considering the demands as to sound-range made by writers on this subject, the demonstrated incompetence of horns and whistles of great reputed power to meet these demands was not encouraging. On the 3rd of June the atmosphere had changed surprisingly. It was loaded overhead with dark and threatening clouds; the sounds, nevertheless, were well heard beyond 9 miles. On June 10th the acoustic transparency of the air was also very fair, the distance penetrated being upwards of $8\frac{3}{4}$ miles. The subsidence of the sound near the boundary of the acoustic shadow on the Dover side of the Foreland, and before entering the shadow, was to-day sudden and extraordinary, affecting equally both horns and guns. We were warned on June 3 that the supremacy of the gun on one occasion by no means implied its supremacy on all occasions,

the self-same guns which on May 20th had so far transcended the horns being on this day their equals and nothing more. The 11th of June was employed in mastering still further the facts relating to the subsidence of the sound east and west of the Foreland; the cause of this subsidence being in part due to the weakening of the sonorous waves by their divergence into the sound shadow, and in part to interference.

The atmosphere on the 25th of June was again very defective acoustically. The sounds reached a maximum distance of $6\frac{1}{2}$ miles; but at 4 miles, on returning from the maximum distance, they were very faint. The day had, as it were, darkened acoustically. On this day the guns lost still further their preeminence, and at $5\frac{1}{2}$ miles were inferior to the horn. No sounds whatever reached Dover Pier on the 11th; and it was only towards the close of the day that they succeeded in reaching it on the 25th. Thus by slow degrees the caprices of the atmosphere made themselves known to us, showing us subsequently that within the limits of a single day, even within a single minute, the air, as a vehicle of sound, underwent most serious variations. The 26th of June was a far better day than its predecessor, the acoustic range being over $9\frac{1}{4}$ miles. The direction of the wind was less favourable to the sound on this day than on the preceding one, plainly proving that something else than the wind must play an important part in shortening the sound-range.

On the 1st of July we experimented upon a rotating horn, and heard its direct or axial blast, which proved to be the strongest, at a distance of $10\frac{1}{2}$ miles. The sounds were also heard at the Varne light-ship, which is $12\frac{3}{4}$ miles from the Foreland. The atmosphere had become decidedly clearer acoustically, but not so optically; for on this day thick haze obscured the white cliffs of the Foreland. In fact, on days of far greater optical purity, the sound had failed to reach one third of the distance attained to-day. In the light of such a fact, any attempt to make optical transparency a measure of acoustic transparency, must be seen to be delusive. On the 1st of July a 12-inch American whistle, of which we had heard a highly favourable account, was tried in place of the 12-inch English whistle; but, like its predecessor, the performance of the new instrument fell behind that of the horns. An interval of 12 hours sufficed to convert the acoustically clear atmosphere of July 1 into an opaque one; for on the 2nd of July even the horn-sounds, with paddles stopped and all noiseless on board, could not penetrate further than 4 miles.

Thus each succeeding day provided us with a virtually new atmosphere, clearly showing that conclusions founded upon one day's observations might utterly break down in the presence of the phenomena of another day. This was most impressively demonstrated on the day now to be referred to. The acoustic imperviousness of the 3rd of July was found to be still greater than that of the 2nd, while the optical purity of the day was sensibly perfect. The cliffs of the Foreland could be seen to-day at ten times the distance at which they ceased to be

visible on the 1st, while the sounds were cut off at one sixth of the distance. At 2 P.M. neither guns nor trumpets were able to pierce the transparent air to a depth of 3, hardly to a depth of 2 miles. This extraordinary opacity was proved conclusively to arise from the irregular admixture with the air of the aqueous vapour raised by a powerful sun. This vapour, though perfectly invisible, produced *an acoustic cloud* impervious to the sound, and from which the sound-waves were thrown back as the waves of light are from an ordinary cloud. The waves thus refused transmission produced by their reflection echoes of extraordinary strength and duration. This I may remark is the first time that audible echoes have been proved to be reflected from an optically transparent atmosphere. By the lowering of the sun the production of the vapour was checked, and the transmissive power of the atmosphere restored to such an extent that, at a distance of 2 miles from the Foreland, at 7 P.M., the intensity of the sound was at least thirty-six times its intensity at 2 P.M.

On October 8 the observations were resumed, a steam syren and a Canadian whistle of great power being added to the list of instruments. A boiler had its steam raised to a pressure of 70 lbs. to the square inch; on opening a valve this steam would issue forcibly in a continuous stream, and the sole function of the syren was to convert this stream into a series of separate strong puffs. This was done by causing a disk with 12 radial slits to rotate behind a fixed disk with the same number of slits. When the slits coincided a puff escaped; when they did not coincide the outflow of steam was interrupted. Each puff of steam at this high pressure generated a sonorous wave of great intensity; the successive waves linking themselves together to a musical sound so intense as to be best described as a continuous explosion.

During the earlier part of October 8 the optical transparency of the air was very great; its acoustic transparency, on the other hand, was very defective. Clouds blackened and broke into a rain- and hail-shower of tropical violence. The sounds, instead of being deadened were improved by this furious squall; and, after it had lightened, thus lessening the local noises, the sounds were heard at a distance of $7\frac{1}{2}$ miles distinctly louder than they had been heard through the preceding rainless atmosphere at a distance of 5 miles. At 5 miles distance, therefore, the intensity of the sound had been at least doubled by the rain—a result entirely opposed to all previous assertions, but an obvious consequence of the removal by condensation and precipitation of that vapour the mixture of which with the air had been proved so prejudicial to the sound. On this day a dependence was established between the pitch of a note and its penetrative power—the syren generating 480 waves being slightly inferior to the horns, while generating 400 waves a second it was distinctly superior. The maximum range on October 8 was 9 miles. On October 9 the transmissive power had diminished, the maximum range being $7\frac{1}{2}$ miles. On

both these days the syren proved to be superior to the horns, and on some occasions superior to the gun.

On the 10th and 11th, a gale having caused our steamer to seek safety in the Downs, we made land-observations. The duration of the aërial echoes was for the syren and the gun 9 seconds, for the horns 6 seconds. The duration varies from day to day. We sought to estimate the influence of the violent wind, and found that the sound of the gun failed to reach us in two cases at a distance of 550 yards to windward, the sound of the syren at the same time rising to a piercing intensity. To leeward the gun was heard at five times, and certainly might have been heard at fifteen times the distance attained to windward. The momentary character of the gun-sound renders it liable to be quenched by a single puff of wind; but sounds of low pitch generally, whether momentary or not, suffer more from an opposing wind than high ones. We had on the 13th another example of the powerlessness of heavy rain to deaden sound.

On the 14th the maximum range was 10 miles, but the atmosphere did not maintain this power of transmission. It was a day of extreme optical clearness; but its acoustic clearness diminished as the day advanced. In fact the sun was in action. We proved to-day that by lowering the pitch of the Canadian whistle, its sound, which had previously been inaudible, became suddenly audible. The day at first was favourable to the transmission of the longer sound-waves. After a lapse of three hours the case was reversed, the high-pitched syren being then heard when both gun and horns were inaudible. But even this state of things did not continue, so rapid and surprising are the caprices of the atmosphere. At a distance of 5 miles, at 3.30 P.M., the change in transmissive power reduced the intensity of the sound to at least one half of what it possessed at 11.30 A.M., the wind throughout maintaining the same strength and direction. Through all this complexity the knowledge obtained on July 3 sheds the light of a principle which reduces to order the apparent confusion.

October 15 was spent at Dungeness in examining the performance of Daboll's horn. It is a fine instrument, and its application was ably worked out by its inventor; still it would require very favourable atmospheric conditions to enable it to warn a steamer before she had come dangerously close to the shore. The direction in which the aërial echoes return was finely illustrated to-day, that direction being always the one in which the axis of the horn is pointed.

The 16th was a day of exceeding optical transparency, but of great acoustic opacity. The maximum range was only 5 miles. On this day the howitzer and all the whistles were clearly overmastered by the syren. It was, moreover, heard at $3\frac{1}{2}$ miles with the paddles going, while the gun was unheard at $2\frac{1}{2}$ miles. With no visible object that

could possibly yield an echo in sight, the pure aërial echoes, coming from the more distant southern air, were distinct and long-continued at a distance of 2 miles from the shore. Near the base of the Foreland cliff we determined their duration and found it to be 11 seconds, while that of the best whistle echoes was 6 seconds. On this day three whistles, sounded simultaneously, were pitted against the syren, and found clearly inferior to it.

On the 17th four horns were compared with the syren and found inferior to it. This was our day of greatest acoustic transparency, the sound reaching a maximum of 15 miles for the syren, and of more than 16 for the gun. The echoes on this day were continued longer than on any other occasion. They continued for 15 seconds, their duration indicating the atmospheric *depth* from which they came.

On October 18, though the experiments were not directed to determine the transmissive power of the air, we were not without proof that it continued to be high. From 10 to 10.30 A.M., while waiting for the blasts of the syren at a distance of 3 miles from the Foreland, the continued reports of what we supposed to be the musketry of skirmishing parties on land were distinctly heard by us all. We afterwards learned that the sounds arose from the rifle-practice on Kingsdown beach, $5\frac{1}{2}$ miles away. On July 3, which, optically considered, was a far more perfect day, the 18-pounder, howitzer, and mortar failed to make themselves heard at half this distance. The 18th was mainly occupied in determining the influence of pitch and pressure on the syren-sound. Taking the fluctuations of the atmosphere into account, I am of opinion that the syren, performing from 2000 to 2400 revolutions a second, or, in other words, generating from 400 to 480 waves per second, best meets the atmospheric conditions. We varied the pressure from 40 to 80 lbs. on the square inch; and though the intensity did not appear to rise in proportion to the pressure, the higher pressure yielded the hardest and most penetrating sound.

The 20th was a rainy day with strong wind. Up to a distance of $5\frac{1}{2}$ miles the syren continued to be heard through the sea- and paddle-noises. In rough weather, indeed, when local noises interfere, the syren-sound far transcends all other sounds. On various occasions to-day it proved its mastery over both gun and horns. On the 21st the wind was strong and the sea high. The horn-sounds, with paddles going, were lost at 4 miles, while the syren continued serviceable up to $6\frac{1}{2}$ miles. The gun to-day was completely overmastered. Its puffs were seen at the Foreland; but its sound was unheard when the syren was distinctly heard. Heavy rain failed to damp the power of the syren. The whistles were also tried to-day, but were found far inferior to the syren. On the 22nd it blew a gale, and the 'Galatea' quitted us. We made observations on land on the influence of the wind and of local noises. The shelter of the Coastguard Station at Cornhill enabled us to hear gun-sounds

which were quite inaudible to an observer out of shelter; in the shelter also both horn and syren rose distinctly in power; but they were also heard outside when the gun was quite unheard. As usual the sound to leeward was far more powerful than those at equal distances to windward. The echoes from the cloudless air were to-day very fine. On the 23rd, in the absence of the steamer, the observations on the influence of the wind were continued. The quenching of the gun-sounds, in particular, to windward was well illustrated. All the sounds, however, gun included, were carried much further to leeward than to windward. The effect of a violent thunderstorm and downpour of rain in exalting the sound was noticed by observers both to windward and to leeward of the Foreland. In the rear of the syren its range to-day was about a mile. At right angles to the axis, and to windward, it was about the same. To leeward it reached a distance of $7\frac{1}{3}$ miles.

On the 24th, when observations were made afloat in the steam-tug 'Palmerston,' the syren exhibited a clear mastery over gun and horns. The maximum range was $7\frac{3}{4}$ miles. The wind had changed from W.S.W. to S.E., then to E. As a consequence of this, the syren was heard loudly in the streets of Dover. On the 27th the wind was E.N.E.; and the syren-sound penetrated everywhere through Dover, rising over the moaning of the wind and all other noises. It was heard at a distance of 6 miles from the Foreland on the road to Folkestone, and would probably have been heard all the way to Folkestone had not the experiments ceased. Afloat and in the axis, with a high wind and sea, the syren, and it only, reached to a distance of 6 miles; at 5 miles it was heard through the paddle noises. On the 28th further experiments were made on the influence of pitch, the syren when generating 480 waves a second being found more effective than when generating 300 waves a second. The maximum range in the axis on this day was $7\frac{1}{2}$ miles.

The 29th of October was a day of extraordinary optical transparency but by no means transparent acoustically. The gun was the greatest sufferer. At first it was barely heard at 5 miles; but afterwards it was tried at $5\frac{1}{2}$, $4\frac{1}{2}$, and $2\frac{1}{2}$ miles, and was heard at none of these distances. The syren at the same time was distinctly heard. The sun was shining strongly; and to its augmenting power the enfeeblement of the gun-sound was doubtless due. At $3\frac{1}{2}$ miles, subsequently, dead to windward, the syren was faintly heard; the gun was unheard at $2\frac{3}{4}$ miles. On land the syren and horn-sounds were heard to windward at 2 to $2\frac{1}{2}$ miles, to leeward at 7 miles; while in the rear of the instruments they were heard at a distance of 5 miles, or five times as far as they had been heard on October 23.

The 30th of October furnished another illustration of the fallacy of the notion which considers optical and acoustic transparency to go hand in hand. The day was very hazy, the white cliffs of the Foreland at the greater distances being quite hidden; still the gun- and syren-sounds

reached on the bearing of the Varne light-vessel to a distance of $11\frac{1}{2}$ miles. The syren was heard through the paddle-noises at $9\frac{1}{4}$ miles, while at $8\frac{1}{2}$ miles it became efficient as a signal with the paddles going. The horns were heard at $6\frac{1}{4}$ miles. This was during calm. Subsequently, with a wind from the N.N.W., no sounds were heard at $6\frac{1}{2}$ miles. On land, the wind being across the direction of the sound, the syren was heard only to a distance of 3 miles N.E. of the Foreland; in the other direction it was heard plainly on Folkestone Pier, 8 miles distant. Both gun and horns failed to reach Folkestone.

Wind, rain, a rough sea, and great acoustic opacity characterized October 31. Both gun and horns were unheard 3 miles away, the syren at the same time being clearly heard. It afterwards forced its sound with great power through a violent rain-squall. Wishing the same individual judgment to be brought to bear upon the sounds on both sides of the Foreland, in the absence of our steamer, which had quitted us for safety, I committed the observations to Mr. Douglass. He heard them at 2 miles on the Dover side, and on the Sandwich side, with the same intensity, at 6 miles.

A gap (employed by the engineers in making arrangements for pointing the syren in any required direction) here occurred in our observations. They were resumed, however, on November 21, when comparative experiments were made upon the gun and syren. Both sources of sound, when employed as fog-signals, will not unfrequently have to cover an arc of 180°; and it was desirable to know with greater precision how the sound is affected by the direction in which the gun or syren is pointed.

The gun, therefore, was in the first instance pointed on us and fired, then turned and fired along a line perpendicular to that joining us and it. There was a sensible, though small, difference between the sounds which reached us in the two cases. A similar experiment was made with the syren; and here the falling off when the instrument was pointed perpendicular to the line joining us and it was very considerable. This is what is to be expected; for the trumpet associated with the syren is expressly intended to gather up the sound and project it in a certain direction, while no such object is in view in the construction of the gun. The experiments here referred to were amply corroborated by others made on November 22 and 23.

On both of these days the 'Galatea's' guns were fired to windward and to leeward. The aërial echoes in the latter case were distinctly louder and longer than in the former. The experiment has been repeated many times, and always with the same result.

In front of the Cornhill Coastguard Station, and only $1\frac{1}{4}$ mile from the Foreland, the syren, on the 21st, though pointed towards us, fell suddenly and considerably in power. Before reaching Dover Pier it had ceased to be heard. The wind was here against the sound; but this, though it contributed to the effect, could not account for it, nor could the

proximity of the shadow account for it. To these two causes must have been added an acoustically flocculent though optically transparent atmosphere. The experiment demonstrates conclusively that there are atmospheric and local conditions which, when combined, prevent our most powerful instruments from making more than a distant approach to the performance which writers on fog-signals have demanded of them.

On November 24 the sound of the syren pointed to windward was compared at equal distances in front of and behind the instrument. It was louder to leeward in the rear, than at equal distances to windward in front. Hence, in a wind, the desirability of pointing the instrument to windward. The whistles were tested this day in comparison with the syren deprived of its trumpet. The Canadian and the 8-inch whistles proved the most effective; but the naked syren was as well heard as either of them. As regards opacity, the 25th of November almost rivalled the 3rd of July. The gun failed to be heard at a distance of 2·8 miles, and it yielded only a faint crack at $2\frac{1}{2}$ miles.

Meanwhile this investigation has given us a knowledge of the atmosphere in its relation to sound, of which no notion had been previously entertained. While the *velocity* of sound has been the subject of refined and repeated experiments, I am not aware that since the publication of a celebrated paper by Dr. Derham, in the Philosophical Transactions for 1708, any systematic inquiry has been made into the causes which affect the *intensity* of sound in the atmosphere. Derham's results, though obtained at a time when the means of investigation were very defective, have apparently been accepted with unquestioning trust by all subsequent writers—a fact which is, I think, in some part to be ascribed to the *à priori* probability of his conclusions.

Thus Dr. Robinson, relying apparently upon Derham, says, "Fog is a powerful damper of sound," and he gives us physical reason why it must be so. "It is a mixture of air and globules of water, and at each of the innumerable surfaces where these two touch, a portion of the vibration is reflected and lost." And he adds further on, "The remarkable power of fogs to deaden the report of guns has been often noticed."

Assuming it, moreover, as probable that the measure of "a fog's power in stopping sound" bears some simple relation to its opacity for light, Dr. Robinson, adopting a suggestion of Mr. Alexander Cunningham, states that "the distance at which a given object, say a flag or pole, disappears, may be taken as a measure of the fog's power" to obstruct the sound. This is quite in accordance with prevalent notions; and granting that the sound is dissipated, as assumed, by reflection from the particles of fog, the conclusion follows that the greater the number of the reflecting particles, the greater will be the waste of sound. But the number of particles, or, in other words, the density of the fog, is declared by its action upon light; hence the optical opacity will be a measure of the acoustic opacity.

This, I say, expresses the opinion generally entertained, "clear still air" being regarded as the best vehicle for sound. We have not, as stated above, experimented in really dense fogs; but the experiments actually made entirely destroy the notion that clear weather is necessarily better for the transmission of sound than thick weather. Some of our days of densest acoustic opacity have been marvellously clear optically, while some of our days of thick haze have shown themselves highly favourable to the transmission of sound. Were the physical cause of the sound-waste that above assigned, did that waste arise in any material degree from reflection at the limiting surfaces of the particles of haze, this result would be inexplicable.

Again, Derham, as quoted by Sir John Herschel, says that "falling rain tends powerfully to obstruct sound." We have had repeated reversals of this conclusion. Some of our observations have been made on days when rain and hail descended with a perfectly tropical fury; and in no single case did the rain deaden the sound; in every case, indeed, it had precisely the opposite effect.

But falling snow, according to Derham, offers a more serious obstacle than any other meteorological agent to the transmission of sound. We have not extended our observations at the South Foreland into snowy weather; but an observation of my own made on December 29th, in the Alps, during a heavy snow-storm, distinctly negatives the statement of Derham.

Reverting to the case of fog, I am unable in modern observations to discover any thing conclusive as to its alleged power of deadening sound. I had the pleasure of listening to a very interesting lecture on fog-signals delivered by Mr. Beazeley before the United-Service Institution; and I have carefully perused the printed report of that lecture, and of a paper previously communicated by Mr. Beazeley to the Institution of Civil Engineers. But in neither of these painstaking compilations can I find any adequate evidence of the alleged power of fogs to deaden sound.

Indeed during the discussion which followed the reading of Mr. Beazeley's paper, an important observation in an opposite sense was mentioned by Mr. Douglass, to whose ability and accuracy as an observer I am able to bear the strongest testimony. Mr. Douglass stated that he had found in his experience but little difference in the travelling of sound in foggy or in clear weather. He had distinctly heard in a fog, at the Smalls rock in the Bristol Channel, guns fired at Milford Haven, 25 miles away. Mr. Beazeley, moreover, has heard the Lundy-Island gun "at Hartland Point," a distance of 10 miles, during dense fog. Mr. Beazeley's conclusion, indeed, accurately expresses the state of our knowledge when he wrote. In winding up his paper, he admitted "that the subject appeared to be very little known, and that the more it was looked into the more apparent became the fact that the evidence as to the effect of fog upon sound is extremely conflicting." When, therefore, it is alleged, as it is

so often alleged, that the power of fogs to deaden sound is well known, the disjunctive *not* is to be inserted before the predicate.

The real enemy to the transmission of sound through the atmosphere has, I think, been clearly revealed by the foregoing inquiry. That enemy has been proved to be not rain, nor hail, nor haze, nor fog, nor snow —not water in fact in either a liquid or a solid form, but water in a vaporous form, mingled with air so as to render it acoustically turbid and flocculent. This acoustic turbidity often occurs on days of surprising optical transparency. Any system of measures, therefore, founded on the assumption that the optic and acoustic transparency of the atmosphere go hand in hand must prove delusive.

There is but one solution of this difficulty: it is to make the source of sound so powerful as to be able to endure loss by partial reflection, and still retain a sufficient residue for transmission. Of all the instruments hitherto examined by us the syren comes nearest to the fulfilment of this condition; and its establishment upon our coasts will, in my opinion, prove an incalculable boon to the mariner.

An account of the observations made during the recent fog will be included in the paper shortly to be presented to the Society. These observations add the force of demonstration to others recorded in the paper, that fogs possess no such power of stifling sound as that hitherto ascribed to them. Indeed the melting away of fog on December 13th was accompanied by an acoustic darkening of the atmosphere, so great that, at a point midway between the eastern end of the Serpentine, where a whistle was sounded, and the bridge, the sound possessed less than one fourth of the intensity which it possessed on the day of densest fog.

Thus, I think, has been removed the last of a congeries of errors which for more than a century and a half have been associated with the transmission of sound by the atmosphere.

January 22, 1874.

JOSEPH DALTON HOOKER, C.B., President, in the Chair.

The following Paper was read:—

I. "On the Nature and Physiological Action of the Poison of *Naja tripudians* and other Indian Venomous Snakes."—Part II. By T. Lauder Brunton, M.D., Sc.D., M.R.C.P., and J. Fayrer, C.S.I., M.D., F.R.C.P. Lond., F.R.S.E., Surgeon-Major Bengal Army. Communicated by Prof. Huxley, Sec.R.S. Received November 8, 1873.

The effects of the poison of *Naja tripudians* are probably the same as those of *Ophiophagus elaps*, *Bungarus*, Hydrophidæ, and other poisonous